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# Prior activity and forgetting after short-term retention

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# PRIOR ACTIVITY AND FORGETTING AFTER SHORT-TERM RETENTION

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## ABSTRACT

### Prior Activity and Forgetting After Short-term Retention

Three groups of sixteen Lehigh University students demonstrated that prior activity, which may be as short as four seconds, is a significant determinant in the forgetting process. In this multitrial, short-term retention experiment, one group manipulated digit pairs arithmetically, a second group rested, and the third group engaged in controlled verbal activity between trials. The memory task, recalling a word triad, was the same for all subjects. The group which practiced arithmetic manipulations had superior recall scores at all retention intervals. The rest condition produced recall scores lower than the superior group, but higher than the group that engaged in prior verbal activity.

A significant recall improvement was found between the first and second series of duplicate trials. Since there was neither an interaction between conditions, nor an intertrial activity by retention interval interaction, the results offer no explanation for the improvement beyond practice.

To the extent that proactive interference is a factor in the forgetting process, these results support interference theory. They are inconsistent with a theory which postulates decay of memory traces, acoustic discriminations, or temporal retrieval cues as sole factors in forgetting.

In their experiment on short-term retention of individual items, which included practice trials prior to a multitrial test session, Peterson and Peterson (1959) examined correct responses within successive trial blocks to test for the presence of proactive interference. These authors thought that improved recall following short retention interval trials, and diminishing recall following longer retention interval trials would be evidence to support the presence of proactive interference between similar items. Within successive twelve trial blocks, they found progressively better recall for items following 3 and 6 sec. retention intervals. Longer retention intervals, 15 and 18 sec., produced small, but not statistically significant performance improvements over successive trial blocks. Peterson and Peterson concluded that evidence for proactive interference was lacking, and attributed the improved recall performance to practice.

Wickens, Born, and Allen (1963) omitted practice trials in order to test for proactive interference build up within subjects who were naive to the retention task. They measured recall of a single item, a consonant triad or a digit triad, following an 11 sec. retention interval. These authors supported Keppel and Underwood's (1962) finding that a substantial decrement occurs after the first trial, and also found that recall for similar items reaches a minimum within four trials. When these experimenters introduced an unfamiliar stimulus item, e.g., S received a consonant triad for recall after having received a series of digit triads as stimulus items, recall of the unfamiliar stimulus item returned to the level of the first trial.

These authors concluded that massive proactive interference builds up between the first few presentations of similar items, and that it is released by a single presentation of an item from a new stimulus class. Loess (1968) used word triads from a single taxonomic category as a series of stimulus items, and demonstrated proactive interference release when he changed word categories.

Loess (1964) supported the notion that proactive interference builds rapidly, and stabilizes within the first few trials. He also found that multitrial sessions, separated by three weeks, produced similar forgetting curves, and he inferred that proactive interference developed within the experimental session. In a subsequent attempt to find an interval within which proactive interference would dissipate, Loess and Waugh (1967) investigated rest intervals between trials. Rest intervals were 0, 15, 30, and 60 sec. in the first experiment, and 2, 3, and 5 minutes in Experiment II. They also examined successive blocks of 6 trials in Experiment I, and found a consistent, significant retention improvement which they attributed to practice. A combination of results from Experiments I and II led Loess and Waugh to conclude that proactive interference was not dissipated completely in rest intervals less than 60 secs., but dissipated below a measurable level if intervals were lengthened to two minutes or more. The effect of activity in the interval following recall and prior to presentation of the next trial stimulus has not been studied systematically.

The main purposes of this experiment were to investigate the intertrial interval of the Peterson and Peterson procedure as a contributor to the forgetting process by manipulating potential sources of proactive interference, and to separate, if possible, some of the variables which lead to the effect attributed to practice.

Unless intertrial activity is controlled, E must make the unlikely assumption that the interval is functionally neutral. If the recall item is a word triad, an arithmetic task should prevent rehearsal of previous stimulus items, and should minimize formation of new verbal associations. Interference attributable to arithmetic intertrial activity would be relatively independent of intertrial interval, but due to the contribution of successive trials, proactive interference would grow over trials. Intensive rehearsal of a new word list during the intertrial interval should weaken interference from previous stimulus items, but because of its recency and similarity to the stimulus list, word rehearsal should produce maximum proactive interference.

Decay theories of forgetting, which received support from Peterson and Peterson (1959), have picked up new vitality. In order to measure recall errors, Conrad (1967) required Ss, in a short-term retention task, to use a limited response domain. He found that 59% of the errors were acoustically similar to correct items. He believed that the main discrimination characteristic between items was acoustic, and that acoustic characteristics decay. Baddeley and Scott (1971) propose that forgetting results from activity within two memory stores. The primary store is subject to rapid decay; the secondary store is more stable, and shows little forgetting. Baddeley and Scott say that in a multitrial experiment, S is asked to recall the most recent item from a series, and he relies on temporal retrieval cues to discriminate between items.

Since the recall task for all Ss in this experiment is identical, it would be unlikely for performance differences to accrue from practice or from decaying acoustic characteristics. Baddeley and Scott's theory would predict equal recall performance unless intertrial activity disrupted temporal recall cues.

## Method

Subjects. Forty-eight students from the introductory psychology course at Lehigh University participated in order to fulfill a requirement.

Design, Materials, and Apparatus. E prepared 48 lists of word triads, and 48 lists of retention interval sequences which were randomly assigned to 16 Ss in each of three conditions. Word triads, required for practice and experimental trials, came from a list of 664 common four letter nouns. Dr. R. H. Bennett supplied the noun list, and some of the procedural details. In preparing the triad sequences, E avoided placing words in adjacent trials that shared first letters, or had strikingly similar phonemic features. For each S, there were six practice trials, two dummy trials, and 32 test trials. Each test trial had one of the 16 possible combinations of a 4, 8, 12, or 16 sec. retention interval (RI), and a 4, 8, 12, or 16 sec. intertrial activity interval (IAI). All 16 combinations of IAI followed by RI appeared in each half of a test sequence. Except for these restrictions, word ~~tr~~ triad list and RI sequence entries were selected at random.

Ss received stimulus presentations on a translucent glass screen, with rear projection from a Kodak Carousel, 2" x 2" slide projector. Each trial required a five slide sequence which appeared as follows: 1) End of Trial, Prepare for Next Problem, 2) Word triad, e.g., BIRD TRIP RICE, 3) List of two digit numbers, 4) Blank - bright, and either 5-ARITH) List of two digit numbers, 5-REST) Blank - dark, or 5-WORDS) List of five nouns randomly chosen from the remainder of the 664 word pool. A typical S received the first four slides, and either

5-ARITH, 5-REST, or 5-WORDS in his trial series.

All interstimulus intervals were 40 secs. A typical trial sequence was: 1) Ready - 2 sec., 2) Item - 3 sec., 3) RI - 16 sec., 4) Recall - 15 sec., 5) IAI - 4 sec. A Psionix timer-counter, model 1248, Psionix, Inc., Madison, Wis., in conjunction with a Hunter timer, model 111-C, Hunter Mfg. Co., Iowa City, Iowa, provided sequencing and a pulse to the projector. E changed settings for RI and IAI prior to each trial. Since three trays of 2" x 2" slides were required for each experimental session, the first sequence following a tray change was a dummy trial, and the data were not used.

Procedure. In a typical session, S sat at a table which separated him from the eye-level translucent screen. E provided a set of 40 response slips, which were sequentially numbered, and had a space for each word of a correct response.

E read the following: "Your task in this experiment is to remember three common nouns. You will also be doing some simple arithmetic problems. I'll explain the procedure as we go.

"Each trial will start with a slide like this. (Present End of Problem slide.) Get ready for the group of nouns. When the noun slide comes on (Present Item.), read the words aloud. You will see the words for only about a second. Be ready for them, and start reading them aloud as soon as you can. Next is the arithmetic slide. (Present interpolated activity slide.) As soon as you see a slide like this, start by adding the two digits in the upper left hand number, say the sum aloud, then say whether this sum is odd or even. (E demonstrates, making sure S understands what is being done.) Proceed from left to right. Add the digits rapidly and accurately. But, do not be alarmed if you make a few mistakes. Ignore mistakes if you can; try to keep adding digits in a regular cadence. While you are doing the arithmetic, avoid thinking about the words presented on the previous slide. Pay attention only to adding digits. After intervals of a few seconds to nearly a half minute, the numbers disappear, and the screen is lighted uniformly. (Demonstrate.) When this happens, write down the three words you saw on this slip of paper, then turn it face down on a pile to your right. Be concerned only with the three words you saw just before the numbers. Once you see and attempt to recall a set of words, forget them; if possible, write down the words in the order in which they were presented. If your memory gets hazy, duplicate the list the best you can. If you change your mind, make corrections, but be sure the intended answer - the word and its position - is clear. You will have about 15 sec. to write your answer. Work rapidly, and you'll have plenty of time. When the screen changes, the answer sheet should be face down. Even if you haven't finished listing the nouns, stop anyway, and put the answer sheet down. Use the next numbered slip for each new trial, keep them in order, and ignore previous answers.

"Do not get upset if you forget some of the words. If you work hard on the arithmetic, you will almost surely forget some of them.

(For the REST group.) "The change in the screen will be from even light to dark. (Demonstrate.) It will stay this way from a few seconds up to nearly a half minute. Relax and rest during this period.

(For the ARITH group.) "The change in the screen will be from even light to a new set of arithmetic problems. Add the digits in the numbers from left to right, say the sum out loud, and tell if the sum is odd or even, just as you did earlier in the trial. The time for these problems will vary from a few seconds to nearly a half minute.

(For the WORDS group.) "The change in the screen will be from even light to a new set of five words. When the five word set comes on, read the list out loud, about two words per second. If you have time to complete reading the list once, start over again. This time, say the word out loud, then say any other word that your reading prompts you to think of. Keep saying associated words as long as you can continue with at least one word per second. Then, go to the next word on the list, and repeat associations for that word. The time for this word list will vary from a few seconds to nearly half a minute. You will not be asked to recall this word list. The list is only for reading, rehearsal, and for making associations. (Practice word associations until S's proficiency reaches 1 word/sec.)

"Next, the ready signal (Present End of Problem slide.) will come on. Prepare yourself for the next set of three nouns which you will attempt to recall. Are there any questions?

"Let's try another sample trial. This time, you go through the procedure; I'll make suggestions as we go. (Run through the practice trial. Correct any mistakes the S makes, and make sure he understands the procedure. Then, practice the arithmetic problems for several minutes; let S practice until he performs the task smoothly, at a rate approximating one digit pair per second.)

"Now we are ready to start the test. The thirty-eight trials in this test will be presented without interruption. Are there any questions before we start?"

From trial three to the end of the session, E operated the sequencing apparatus from the projector room, and monitored S's verbal output via intercom.

E scored each response slip as follows: 1) Number of correct words in proper position, 2) Number of correct words in the wrong position, and 3) Number of intrusions. An intrusion was an identifiable word that was not in the stimulus item, a misspelled word, or an otherwise unidentifiable response having two letters or more. Blanks and single letter responses counted as omissions. By referring to the stimulus lists, E identified intrusions which came from previous stimulus items. Wickens has proposed a composite retention score, cited in Keppel (1965), which considered partial recall of word triads as well as the entire item. The retention measure used in this study followed Wickens, and included Conrad's (1967) notion that overt intrusions represent severely degraded traces. For each trial, the composite response score could range from +4 to -3. Four represented correct recall of the word triad, correct words in any order contributed 1, 2, or 3 to the composite score, while intrusions contributed -1, -2, or -3. In order to simplify comparisons with other studies, group retention scores are represented as percent recall. E transformed the composite score to a scale that ranged from 0 to 7, and assumed that completely correct responses represented 100% recall, while overt intrusions at all response opportunities represented zero recall.

## Results

The overall analysis of variance indicated significant effects for intertrial activity, $F\ (2,45) = 8.26$, $p < 0.01$, between first and second halves, $F\ (1, 45) = 9.25$, $p < 0.01$, and, of course, retention interval, $F\ (3, 135) = 107.43$, $p < 0.01$. The fourth main effect, intertrial activity interval, did not reach significance. There were no significant interactions.

Figure 1 illustrates the effect of intertrial activity. It shows that groups, which have engaged in various prior activities, perform differently when they attempt an identical memory task. ARITH, REST, and WORDS designate the experimental groups whose pretrial activity consisted of manipulating digits, rest, and intensive verbal exercise. Each point in the figure represents 128 responses. A Newman-Keuls procedure, which tested the difference between all possible means in the 4 sec. RI category, a posteriori, showed that ARITH differed from REST and WORDS, but there was no significant difference between REST and WORDS. For the difference, $p < 0.05$.

Table 1 shows the effect between the first and second halves of the experiment.

Table 2 represents auxiliary retention measures which show qualitative as well as quantitative differences between group recall performances.

When completely correct word triads are plotted as a function of retention interval, Figure 2, the REST retention curve corresponds closely with Peterson and Peterson's (1959) experiment and Murdock's (1961) replication.

## Discussion

If there is a continuum in the forgetting process between short-term and long-term memory, Melton (1963), interference theory leads to the prediction that growing proactive interference would result in gradually diminishing retention over trials, and the effect should be greater following long retention intervals than after short ones. Instead of diminishing, recall performance improved over trials.

Keppel and Underwood (1962) provided some evidence to show that phenomena explained by proactive inhibition were similar for short- and long-term memory. They found that within the first six trials of a short-term retention experiment, recall performance, following an 18 sec. RI, decreased as a function of prior items. Recall following a 3 sec. RI remained relatively stable. The first scored trials in this experiment followed six practice trials which allowed maximum proactive interference to build up. The effect over trials was derived from successive blocks of 16 trials. Interference theory would predict the greatest performance differential between ARITH and WORDS at longer RIs, with lesser differentials at short RIs. Since the interaction did not appear, the performance improvement may be attributable to practice in the experimental setting.

Unless stimulus traces are laid down differently for ARITH, REST, and WORDS, this design should allow performance predictions based on trace decay theories of forgetting. Since the memory task and the interpolated activity in the RIs are identical for each group, a single factor trace decay theory would predict no difference in recall scores. Conrad (1967) attributed forgetting mainly to decaying acoustic characteristics of the stimulus item. Since stimulus items were randomly distributed, the acoustic characteristics decay theory would predict no recall differences. Since ARITH, REST, and WORDS showed substantial differences in recall, and in qualitative responses, their performances did not support a trace decay theory.

The 4 sec. RI falls within the primary, rapid decay memory store described by Baddeley and Scott (1971). Longer RIs reflect the forgetting process in the secondary store. If forgetting is mainly attributable to the decay of temporal cues, there would be no difference in recall scores at the 4 sec. RI, but differences may appear at longer RIs due to disrupted retrieval cues. Intensive verbal activity should have the most disrupting influence, while rest between trials would interfere least. Recall differences, which appeared after the 4 sec. RI, removed any support for a primary memory store that is depleted by trace decay.

The investigator was surprised to find that ARITH demonstrated the best recall performance. Interference theory led to the prediction that ARITH would outperform WORDS, but could not predict the relative performance of REST. From an information processing standpoint, ARITH and WORDS experienced the "high rate of information transmission through the nervous system" that Broadbent (1963) proposed as an explanation of interference effects, but REST had a passive period in which to prepare for the next stimulus item. It seemed reasonable that intensive intertrial activity might disrupt retrieval cues that would otherwise lead to correct responses. With equivalent temporal cues, and differences in the intensity of prior activity, the experimenter thought that REST would perform better than ARITH, and WORDS would record the poorest performance at all RIs. REST subjects were free to rehearse prior items, consolidate prior errors, or form extralist associations. This experiment showed that the intertrial interval is not neutral, and that rest between trials can promote forgetting more than controlled activity. Intertrial activity determines qualitative response features as well as quantitative recall performance.

Since it has been repeatedly demonstrated that proactive interference can be released within one trial (Wickens, Born, and Allen (1963), Turvey (1968), and Loess and Waugh (1968)), and these results indicate that prior activity, within a 4 sec. interval, is also a determinant in the forgetting process, proactive interference does not simply accumulate over trials. It must have a protean component that is situation dependent. That component may explain some of the wide ranging differences observed in short-term retention studies.

TABLE 1

Percent Recall, a Composite Retention Measure,

in Successive Trial Blocks

First half %, (second half %)

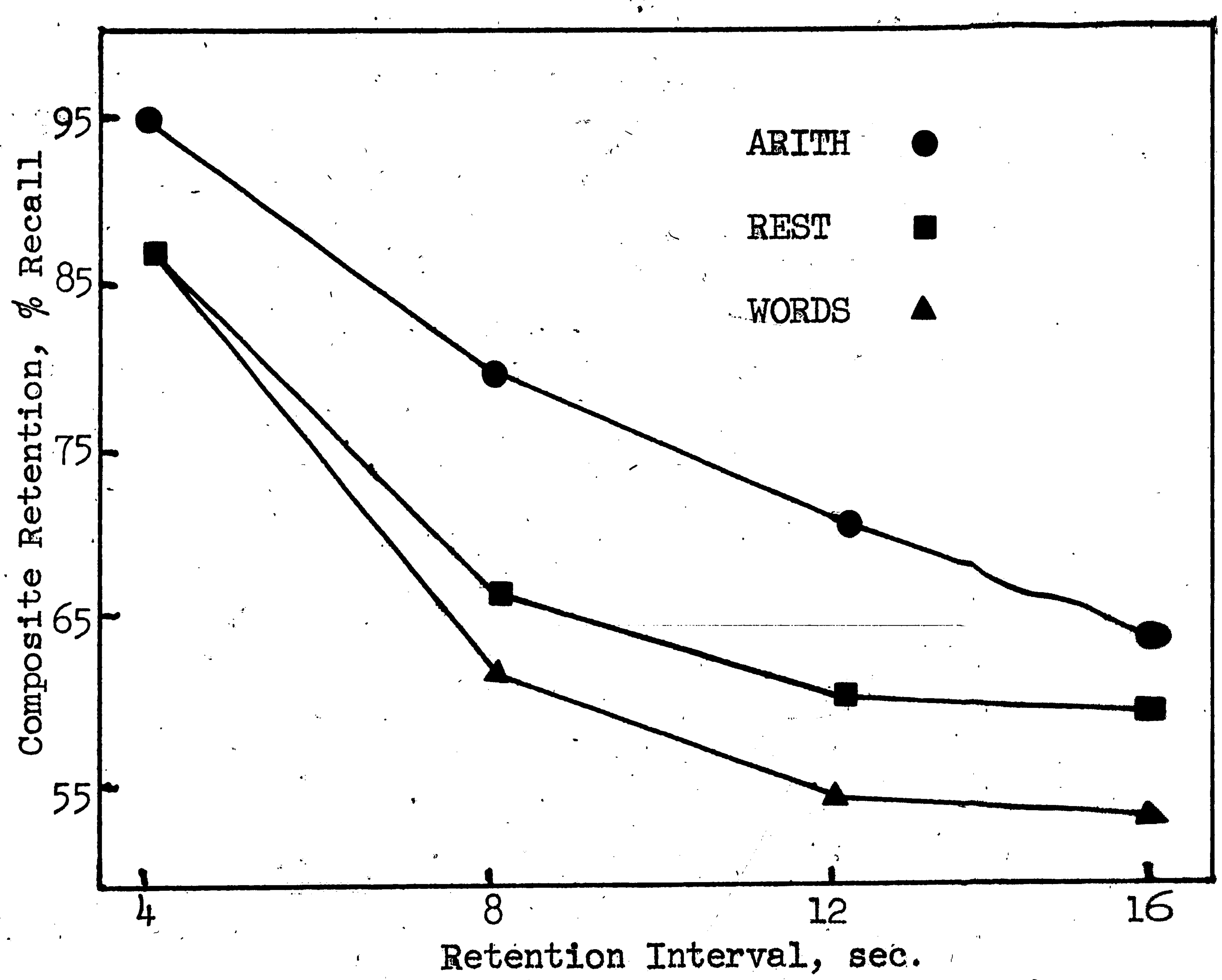
| Group | 4 sec. RI | 8 sec. RI | 12 sec. RI | 16 sec. RI |
|---|---|---|---|---|
| ARITH | 93, (97) | 77, (83) | 68, (76) | 57, (68) |
| REST | 86, (88) | 67, (66) | 61, (59) | 58, (61) |
| WORDS | 85, (88) | 64, (61) | 49, (59) | 51, (56) |

TABLE 2

Auxiliary Retention Measures

| Group | Word triads completely correct | Intrusions, % of all responses | Intrusions, % from previous trial | Ratio of intrusions to omissions |
|---|---|---|---|---|
| ARITH | 47.7% | 10.1 | 17.4 | 0.67 |
| REST | 32.8% | 13.4 | 17.0 | 0.56 |
| WORDS | 28.3% | 18.1 | 7.5 | 0.77 |

Figure 1..Group performance on a composite retention measure following three different pretrial activities.



ARITH
REST
WORDS
Composite Retention, % Recall
95
85
75
65
55
4
8
12
16
Retention Interval, sec.

Figure 2. Word triads correctly recalled as a function of retention interval. A comparison with Peterson and Peterson ([illegible]) and Murdock (1961).

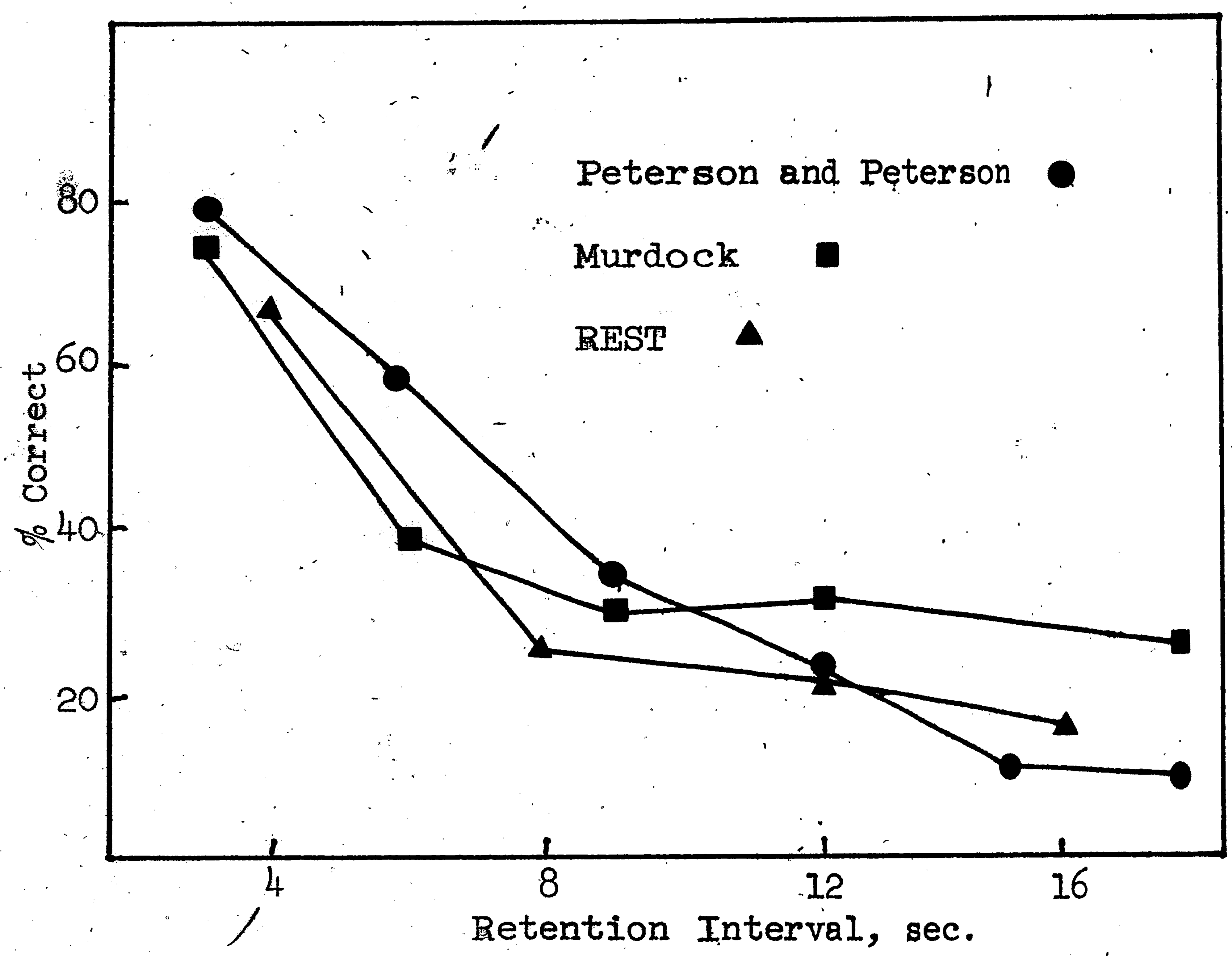

Peterson and Peterson
Murdock
REST
80
60
40
20
% Correct
4
8
12
16
Retention Interval, sec.

TABLE 3

Summary of Analysis of Variance

| Source | Sum of Squares | df | Mean Squares | F |
|---|---|---|---|---|
| A - Intertrial Activity | 235.5469 | 2 | 117.7735 | 8.26** |
| Error - A | 641.7656 | 45 | 14.2615 | |
| B - Retention Interval | 1084.1927 | 3 | 361.3976 | 107.43** |
| AB | 36.4792 | 6 | 6.0799 | 1.81 |
| Error - B | 454.1406 | 135 | 3.3640 | |
| C - Intertrial Interval | 10.3125 | 3 | 3.4375 | 1.63 |
| AC | 24.8281 | 6 | 4.1381 | 1.96 |
| Error - C | 284.9219 | 135 | 2.1106 | |
| D - 1st Half, 2nd Half | 26.0417 | 1 | 26.0417 | 9.25** |
| AD | 12.2708 | 2 | 6.1354 | 2.18 |
| Error - D | 126.6250 | 45 | 2.8139 | |
| BC | 30.4323 | 9 | 3.3814 | 1.56 |
| ABC | 38.9583 | 18 | 2.1644 | 1.00 |
| Error - BC | 879.0469 | 405 | 2.1705 | |
| BD | 7.2761 | 3 | 2.4254 | 1.01 |
| ABD | 11.5989 | 6 | 1.9332 | 0.80 |
| Error - BD | 324.6875 | 135 | 2.4051 | |
| CD | 1.1875 | 3 | 0.3959 | 0.19 |
| ACD | 4.3438 | 6 | 0.7240 | 0.35 |
| Error - CD | 279.2812 | 135 | 2.0688 | |
| BCD | 10.4322 | 9 | 1.1592 | 0.52 |
| ABCD | 30.1260 | 18 | 1.6737 | 0.75 |
| Error - BCD | 903.1563 | 405 | 2.2301 | |

** $p < 0.01$.

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## Vita

Gordon Ault was born in San Diego, California on November 11, 1917. He attended college in Berkeley, California. He received a Bachelor of Science degree, with a major in Chemistry, from the University of California in May, 1939.

While he was employed in the chemical industry, he resumed academic training at Kansas City, Missouri. Majoring in Counseling and Guidance, he received a Master of Arts degree from the University of Missouri at Kansas City in January, 1969.